TT 26 Transport - Poster Session

Time: Wednesday 14:30–18:30 Room: P1

TT 26.1 Wed 14:30 P1

Heat transport in ac-driven nanostructures — •Michael Strass[1], Miguel Rey[2], Sigmund Kohler[1], Fernando Sols[3], and Peter Hänggi[1] — [1]Institut für Physik, Universität Augsburg, 86135 Augsburg — [2]Departamento de Física Teórica de la Materia Condensada, Universidad Autónoma de Madrid, 28049 Madrid, Spain — [3]Departamento de Física Teórica de Materiales,Universidad Complutense de Madrid, 28040 Madrid, Spain

The charge transport in nanoscale conductors driven by an external, alternating electric field is subject to many recent studies, whereas the mechanisms of heat transfer of nanoconductors far from equilibrium are fairly unknown. In our model calculations, we consider an ac-driven system connected to two leads. The heat current defined by the energy transfer from one metallic lead to the central region is computed with a Floquet theory making use of the time periodicity of the driving. In particular, thermo-electric effects of a ac-driven two-level system induced by a finite temperature difference in the leads are investigated. Open double-quantum dots represent an ideal realization for those kind of systems. The results obtained by the Floquet approach are compared to a different numerical treatment based on a transfer-matrix method.

TT 26.2 Wed 14:30 P1

Conductance Measurements on Ferromagnetic Breakjunctions — •Magdalena Hüfner, Cécile Bacca, Martina Suty, and Elke Scheer — Universität Konstanz

We investigate lithographically fabricated breakjunctions of ferromagnetic metals. With the help of a three-point bending mechanism, the bridges can be opened and stabilized to a single-atom contact, broken to a vacuum-tunnel contact and closed again repeatedly at low temperatures ($T \leq 4.2$K). We observe steps in the conductance that are due to atomic rearrangements in the contact region [1] and calculate the preferred conductance value of a single Co atom with and without magnetic field. In addition we observe very high magnetoconductance effects up to 150% for single-atom or 500% for tunnel contacts in magnetic fields up to 5 T and perpendicular to the sample plane. We analyze the magnetoconductance as a function of the symmetry of the contact and of the free-standing bridge length. We developed a sample preparation method for samples the leads of which are made up of different materials than the contact itself and calculated [2] the magnetization state as a function of the geometry of the contact, the film thickness and its magnetic history. First results are presented.

[1] J.M. Krans et al. Nature 375, 767 (1995)
[2] M.J. Donahue and D.J. Porter, OOMMF's User Guide (see http://math.nist.gov/oommf)

TT 26.3 Wed 14:30 P1

Analytic and numeric Green's functions for a two-dimensional electron gas in an orthogonal magnetic field — •Alessandro Cresti[1,2], Giuseppe Grosso[2], and Giuseppe Pastori Parravicini[3] — [1]NEST-INFM and Scuola Normale Superiore, Piazza dei Cavalieri 7, I-56126 Pisa, Italy — [2]NEST-INFM and Dipartimento di Fisica 'E. Fermi', Universita' di Pisa, Largo Pontecorvo 3, I-56127 Pisa, Italy — [3]NEST-INFM and Dipartimento di Fisica 'A. Volta', Universita' di Pavia, Via A. Bassi 6, I-27100 Pavia, Italy

We have derived closed analytic expressions for the Green's function of an electron in a two-dimensional electron gas threaded by a uniform perpendicular magnetic field, also in the presence of a uniform electric field and of a parabolic spatial confinement. A workable and powerful numerical procedure for the calculation of the Green's functions for a large infinitely extended quantum wire is considered exploiting a lattice model for the wire, the tight-binding representation for the corresponding matrix Green's function, and the Peierls phase factor in the Hamiltonian hopping matrix element to account for the magnetic field. The numerical evaluation of the Green's function has been performed by means of the decimation-renormalization method, and quite satisfactorily compared with the analytic results worked out in this paper. As an example of the versatility of the numerical and analytic tools here presented, the peculiar semilocal character of the magnetic Green's function is studied in detail because of its basic importance in determining magneto-transport properties in mesoscopic systems.

TT 26.4 Wed 14:30 P1

A Setup to measure the influence of defects on conductance fluctuations in metallic nanowires — •Michael Wolz, Vojko Kunej, Christian Debuschewitz, and Elke Scheer — Fachbereich Physik, Universität Konstanz, D-78457 Konstanz

The goal of the project is to investigate the influence of individual artificial defects on the conductance fluctuation of metallic nanowires. An STM working in a conventional cryostat at 4 K and in magnetic fields up to 1 T has been developed for creating the defects. In order to position the sample with respect to the STM tip the system is equiped with an x-y-table. The nanostructures are fabricated by electron beam lithography and reactive ion etching [1]. The accessibility of the samples by the STM tip is realized by shadow evaporation of the metal (Au) onto the substrate. First low-temperature transport measurements are presented.

[1] T. Hoss et al., Physica E 14 (2002) 341

TT 26.5 Wed 14:30 P1

Electron transport and current fluctuations in short coherent conductors — •Dmitry Golubev, Artem Galaktionov, and Andrei Zaikin — Forschungszentrum Karlsruhe, Institut fuer Nanotechnologie, 76021 Karlsruhe, Germany

Employing a real time effective action formalism we analyze electron transport and current fluctuations in comparatively short coherent conductors in the presence of electron-electron interactions. We demonstrate that, while Coulomb interaction tends to suppress electron transport, it may *strongly enhance* shot noise in scatterers with highly transparent conducting channels. This effect of excess noise is governed by the Coulomb gap observed in the current-voltage characteristics of such scatterers. Our results illustrate a direct relation between electron-electron interaction effects and current fluctuations in disordered mesoscopic conductors.

TT 26.6 Wed 14:30 P1

The role of contacts in transport through Luttinger liquid — •Katharina Janzen, Volker Meden, and Kurt Schönhammer — Friedrich Hund Platz 1 , 37077 Göttingen

We investigate how the linear conductance through a clean Luttinger liquid (quasi one-dimensional quantum wire of correlated electrons) is effected by the contacts. Two models are studied. In the first the inhomogeneous system is described by an effective hydrodynamic model (local Luttinger liquid) obtained from bosonization. Within this approach analytical results can be obtained that generalize earlier findings. In addition, we study a microscopic lattice model applying the functional renormalization group method. This allows a more detailed analysis of problem.

TT 26.7 Wed 14:30 P1

Anomalies in Coupled Quantum Chains as resonances of the bands — •Luca Alloatti[1] and Giuseppe Grosso[2] — [1]Max-Planck Institut fuer Metallforschung, Heisenbergstr. 3, D-70569 Stuttgart, Germany — [2]NEST-INFM and Dipartimento di Fisica "E. Fermi", Universita' di Pisa, Via F. Buonarroti 2, I-56127 Pisa, Italy

We consider the disordered quasi-one-dimensional single particle tight-binding hopping model and we show that the anomalies in the density of states, in the mean conductance and the even-odd effect are related to a resonance of the band structure of the perfect system underlying the disorder and not necessarily to the E=0 point. For the one-dimensional case we calculate the coefficients of the perturbation expansion of the mean conductance up to the twelfth order for both the pure diagonal and real off-diagonal disorder. This calculation evidences a profound difference between the two cases. In the case of two coupled chains we calculate the same expansion to the the fourth order and for general disorder. This is sufficient to make important predictions well verified numerically.

TT 26.8 Wed 14:30 P1

Zeeman Ratchets for Ballistic Spin Currents — •Matthias Scheid, Dario Bercioux, and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, Germany

We investigate the possiblity of creating directed spin-polarized currents in a two-dimensional electron gas (2DEG) subject to an asymmetric, spatially-periodic magnetic field and an external adiabatic rocking.

Thereby we generalize concepts of quantum charge ratchets [1] to the case with spin. Due to the Zeeman term in the Hamiltonian, spin-up and spin-down electrons experience different effective potentials which can be taylored to achieve net spin currents without corresponding charge currents. We consider ballistic, coherent transport in waveguides defined on a 2DEG, where the magnetic field modulation is, e.g., induced from a periodic array of ferromagnetic stripes on top of the 2DEG.

[1] H. Linke, T. E. Humphrey, A. Löfgren, A. O. Sushkov, R. Newbury, R. P. Taylor and P. Omling, Science **286**, 2314 (1999)

TT 26.9 Wed 14:30 P1

Dephasing by transverse gauge field fluctuations — •Thomas Ludwig[1] and Alexander D. Mirlin[1,2] — [1]Institut fuer Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany — [2]Institut fuer Theorie der Kondensierten Materie, Universitaet Karlsruhe, 76128 Karlsruhe, Germany

We consider the effect of transverse gauge field fluctuations on quantum interference effects in lowdimensional disordered systems. Using a purely diffusive description we reproduce a logarithmic correction to the dephasing rate of the Cooperon in two dimensions first found by Wölfle (2000). In addition, we present new results for the wire geometry where we find a dephasing rate linear in the temperature. Finally, we examine the difference between the dephasing rate due to slow gauge field fluctuations (with frequencies smaller than the dephasing rate) and the dephasing rate due to fast fluctuations (with frequencies larger than the dephasing rate).

TT 26.10 Wed 14:30 P1

Time-dependent Numerical Renormalization Group for Multi-Level Quantum Dots — •David Roosen and Walter Hofstetter — Theoretische Physik A, RWTH Aachen, D-52056 Aachen, Germany

During the last years Kondo phenomena have been realized in a controlled way in quantum dots with odd and even electron number [1]. Recent extensions of the Numerical Renormalization Group (NRG) [2] allow non-perturbative calculations of time-dependent phenomena in the Kondo regime. Here we investigate a two-level lateral quantum dot, taking into account Hund's rule coupling. For this system it has been shown that a singlet-triplet Kondo effect occurs as a function of the level spacing [3]. Applying the time-dependent NRG algorithm of [2], we focus on the evolution of the system after a sudden change in the Hamiltonian, driving the quantum dot from the singlet to a triplet ground state.

[1] D. Goldhaber-Gordon et al., Nature **391**, 156 (1998)
[2] F. Anders and A. Schiller, cond-mat/0505553
[3] W. Hofstetter and H. Schoeller, Phys. Rev. Lett. **88**, 016803 (2002)

TT 26.11 Wed 14:30 P1

Flow equation method for the non-equilibrium Anderson Impurity Model — •Michael Möckel and Stefan Kehrein — LMU München, Lehrstuhl für Theoretische Festkörperphysik,Theresienstraße 37, D-80333 München, Germany

The Anderson impurity model is of central importance in correlated electron physics and is often used as a minimal model for studying quantum dots with Coulomb blockade effects. Steady state non-equilibrium behaviour can be obtained by applying a constant voltage bias across the impurity site. We examine this steady state by means of the flow equation method at zero temperature in the regime of weak to medium correlation strength.

In particular, we study the impurity orbital density of states and the decay of the quasi-particle resonance far away from equilibrium due to current-induced decoherence.

TT 26.12 Wed 14:30 P1

A diagrammatic approach to adiabatic pumping — •Janine Splettstoesser[1,2], Michele Governale[1,2], Jürgen König[2], and Rosario Fazio[1] — [1]Scuola Normale Superiore, Piazza dei Cavalieri, I-56126 Pisa — [2]Institut für Theoretische Physik, Ruhr-Universität Bochum, D-44780 Bochum

We consider adiabatic charge pumping through an interacting single-level quantum dot. We present a general perturbation theory approach for the adiabatic expansion using a diagrammatic technique [1,2] and apply it to the pumped current up to second order Γ contributions in the self energy. It turns out that second leading order contributions of the perturbation expansion of the adiabatically pumped charge are exclusively due to level renormalization effects.

[1] J. König, H. Schoeller, and G. Schön, Phys. Rev. Lett.**76**, 1715 (1996).
[2] J. König, J. Schmid, H. Schoeller, and G. Schön, Phys. Rev. B **54**, 16820 (1996)

TT 26.13 Wed 14:30 P1

Transport properties of a single electron transistor strongly coupled to a nanomechanical resonator — •Charles Doiron[1], Wolfgang Belzig[2], and Christoph Bruder[1] — [1]Department of Physics and Astronomy, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [2]Department of Physics, University of Konstanz, D-78457 Konstanz, Germany

It is now experimentally possible to create nanometer-sized mechanical resonators and to couple them to quantum point contacts or single electron transistor (SET) to study their behaviour.

Previous theoretical studies of the coupled nanomechanical resonator-SET system have focused on the regime where the coupling between the resonator and the SET is weak. In this regime the electrons tunneling trough the SET act like an effective thermal bath, effectively damping the motion of the oscillator [1]. Until now, the strong coupling regime has not been investigated theoretically.

In this work, we use a master-equation approach to describe the coupled SET-nanomechanical resonator system in the strong coupling regime. We compute the dynamics of the resonator as well as the effect of the coupling on the current and noise characteristics of the SET.

[1]A. D. Armour, M. P. Blencowe, and Y. Zhang, Phys. Rev. B **69**, 125313 (2004)

TT 26.14 Wed 14:30 P1

Rabi spectroscopy in a qubit-oscillator system — •Julian Hauss, Alexander Shnirman, and Carsten Hutter — Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe, Germany

In recent years coherent control of JJ-qubits was demonstrated in many experiments. A promising approach towards efficient non-demolition measurement of a JJ-qubit is the readout via a harmonic oscillator coupled to the qubit. In particular, Rabi spectroscopy experiments in such systems were carried out in Jena.

We analyzed theoretically the Rabi spectroscopy in a qubit-oscillator system. We studied the contributions of one- and two-photon processes to the spectroscopic signal and made a comparison with the experimental results.

TT 26.15 Wed 14:30 P1

Creating microwave photon pairs in superconducting cavity QED — •Florian Marquardt — Sektion Physik, Arnold Sommerfeld Center for Theoretical Physics, and Center for NanoScience, Ludwig-Maximilians-Universität München, Theresienstr. 37, 80333 München

With the recent advent of superconducting cavity quantum electrodynamics [1], circuit architectures become possible that process and store quantum information in the form of microwave photons traveling along transmission lines on a chip, interacting with superconducting qubits.

In this talk, I will present and theoretically analyze a setup that may be used to create microwave photon pairs with a very high efficiency. The basic mechanism is parametric down conversion, and the necessary nonlinearity is provided by a charge qubit coupled to a cavity. The main advantage of the scheme is achieved by the fact that the qubit acts as an artificial atom whose parameters are fully tunable and can be optimized. Non-idealities such as non-radiative relaxation and dephasing of the qubit are taken into account employing a Lindblad master equation approach.

[1] A. Wallraff et al., Nature **431**, 162 (2004).

TT 26.16 Wed 14:30 P1

Information transfer in permanently coupled spin chains — •Daniel Burgarth[1], Sougato Bose[1], and Vittorio Giovannetti[2] — [1]Department of Physics & Astronomy, University College London, Gower St., London WC1E 6BT, UK — [2]NEST-INFM & Scuola Normale Superiore, piazza dei Cavalieri 7, I-56126 Pisa, Italy

The transfer of quantum information is a crucial part of any quantum computation. Recently it was suggested to use permanently coupled systems for transferring quantum states. This is especially important in solid state implementations (such as flux qubits) where dynamical control of the couplings is difficult to implement. However, in many cases using permanent couplings leads to dispersion and low fidelity. A proper

choice of the coupling strengths overcomes this problem, but may be too difficult to engineer. We suggest a scheme that allows arbitrarily perfect state transfer even in the presence of random fluctuations in the couplings of a quantum chain. Hence our scheme puts minimal demand not only on the control of the chains when using them, but also on the design when building them. No control is required along the transmission line, but the sender and receiver have to be able to perform quantum gates and measurements.

TT 26.17 Wed 14:30 P1

Phase-space theory for nonlinear detectors of superconducting qubits — •Ioana Serban and Frank Wilhelm — Department Physik. Arnold-Sommerfeld-Center for Theoretical Physics, and Center for Nanoscience, Ludwig-Maximilians-Universitaet, Theresienstr. 37 80333 Muenchen, Germany

Superconducting circuits are envisioned as quantum bits and demonstrate quantum-coherent features i.e. Rabi oscillations and Ramsey fringes. The detector (e.g. a superconducting quantum interference device) can itself be described by a Hamiltonian and treated quantum-mechanically.This allows more insights into the measurement process.

Several experimental groups have realized good detectors with strong coupling to the measured system, where nonlinear dynamics plays a significant role.

Motivated by the recent experiment [1], we study a nonlinear detector where the qubit couples to the square amplitude of a driven oscillator, which can be used for dispersive detection. We use a complex-environment approach treating the qubit and the oscillator exactly, expressing their full Floquet-state master equations in phase space. We investigate the backaction of the environment on the measured qubit and explore the resolution of measurement. We emphasize the resulting role of non-Gaussian and non-Markovian effects in the backaction including significant non-exponential shape of the coherence decay.

[1] A. Lupaşcu et al. PRL 93 177006 (2004)

TT 26.18 Wed 14:30 P1

Microwave spectroscopy on single Josephson junctions — •Karl Madek, Sven Beutner, Renke Stolle, Christian Probst, Achim Marx, and Rudolf Gross — Walther-Meißner-Instiut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

In recent years, interest in quantum computing has been continuously growing. Because of the superconducting energy gap, superconducting devices are promising candidates for qubits with sufficiently large decoherence times.

A prerequisite for the investigation of qubits is a suitable low noise experimental set-up. Performing escape rate measurements on single Josephson junctions with and without microwave irradiation is a convenient way to both test the set-up and establish the experimental methods to manipulate qubits.

Our escape temperature measurements on an SIS tunnel junction without microwave irradiation are in good agreement with theory. They show a crossover from the thermal to the quantum regime and thus prove the negligibility of system noise. In spectroscopic measurements, the junction was excited by single and multiple microwave photons, showing the quantization of the energy levels in the tilted washboard potential. From the experimental results, the intrinsic junction parameters (critical current, plasma frequency) could be determined with high accuracy. Currently, we are performing escape rate measurements on "0"- and "π"SIFS junctions.

This work was supported by the DFG through SFB 631.

TT 26.19 Wed 14:30 P1

SIS and SIFS niobium Josephson junctions for superconducting flux qubits — •Georg Wild, Bernhard Huber, Tobias Heimbeck, Karl Madek, Matteo Mariantoni, Achim Marx, and Rudolf Gross — Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany

Superconducting loops containing Josephson junctions (JJ) are among the most promising candidates for the implementation of quantum computation systems. Unfortunately, the operation point of such a persistent current qubit (PCQB) is around half an applied flux quantum, which is hard to be applied stably and uniformly for systems consisting of a large number of PCQBs. A possibility to circumvent this problem is to insert π-phase-shift elements into the qubit loop. These may be implemented by superconductor/ferromagnet/superconductor (SFS) JJ, where the correlated electron-hole-pairs created by Andreev reflection are modified by the magnetic exchange interaction.

The quality of niobium based Josephson junctions depends crucially on the properties of the relevant interfaces. Therefore, we have developed an in-situ multilayer process to prepare $Nb/AlO_x/Ni_{0.18}Pd_{0.82}/Nb$ stacks. A mesa is defined in the top layers using optical lithography and RIE. After deposing an isolating SiO_2 layer the top niobium electrode is contacted. Transport measurements on SIS and SIFS junctions have been performed to characterize Josephson coupling.

This work was supported by the Sonderforschungsbereich 631 of the Deutsche Forschungsgemeinschaft.

TT 26.20 Wed 14:30 P1

Experimental Realization and Testing of Microwave Beam Splitters — •Andreas Emmert[1], Matteo Mariantoni[1], Henning Christ[2], Enrique Solano[2,3], Markus J. Storcz[4], Frank K. Wilhelm[4], Achim Marx[1], and Rudolf Gross[1] — [1]Walther-Meissner-Institut, Walther-Meissner-Str. 8, D-85748 Garching, Germany — [2]Department Physik, ASC and CeNS, Ludwig-Maximilians-Universität, Theresienstr. 37, D-80333 München, Germany — [3]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, D-85748 Garching, Germany — [4]Sección Física, Departamento de Ciencias, Pontificia Universidad Católica del Perú, Apartado 1761, Lima, Peru.

Balanced quantum homodyne detection and tomography are powerful techniques which allow for the entire Wigner function reconstruction of weak quantum signal in the optical and microwave domains. In both domains, the central device of these schemes is a balanced and lossless beam splitter. As recently proposed [1] (see also presentation TT 19, E. Solano), at microwave frequencies a beam splitter can be implemented on a chip by means of a so-called hybrid ring.

We report on the realization and measurement of the characteristic S-parameters of microwave beam splitters made of Niobium thin films, in a coplanar wave guide design. In particular, the coupling and isolation properties of this device have been experimentally tested. The simple design architecture is suitable for a large scale production. This work was supported by the SFB 631 of the DFG.

[1] M. Mariantoni *et al.*, cond-mat/0509737.

TT 26.21 Wed 14:30 P1

Coupled Josephson Phase Qubits — •T. Wirth[1], J. Lisenfeld[1], A. Lukashenko[1], S. Shitov[2], and A.V. Ustinov[1] — [1]Physikalisches Institut III, Universität Erlangen, Germany — [2]Institute of Radio Engineering and Electronics, Moscow, Russia

Solid-state quantum bits based on current-biased Josephson junctions have recently been shown as very promising. They require appropriate isolation from the bias leads which can be achieved by the use of superconducting transformers. The resulting rf-SQUID has a double-well potential, where the discrete quantum levels in one well can be used as qubit states. State-dependent tunneling to the other well changes the magnetic flux in the qubit, which is measured by a dc-SQUID. We experimentally demonstrate the preparation of an arbitrary quantum state using nanosecond long microwave pulses and observe Rabi oscillations using samples fabricated by a standard foundry. Another crucial point is the coupling of qubits, which we currently study in a system of two capacitively coupled flux-biased phase qubits. Our ongoing experiments are focused on spectroscopic measurements of the coupling strength and the demonstration of coherent interaction in the time domain by observing antiphase oscillation of the two-qubit states at the degeneracy point.

TT 26.22 Wed 14:30 P1

Implementation of two-cell flux qubits — •A. K. Feofanov, A. A. Abdumalikov, and A. V. Ustinov — Physikalisches Institut III, UniversitätErlangen-Nürnberg, Erlangen, Germany

The standard flux qubit implemented at Delft [1] consists of a superconducting loop with three Josephson junctions and features a double well potential at half frustration. Its limitation is that the barrier height cannot be changed without breaking the symmetry. An alternative device proposed by Yukon [2] is a two-cell flux qubit containing four junctions. One of the useful properties of Yukon's qubit is that the barrier height can be controlled without violating the symmetry of the potential, which in turn permits implementation of geometric quantum computation using a Cirac-Zoller [3] type of bus. We have established a technological process for fabricating two-cell qubits based on sub-micron Al-AlO_x-Al Joseph-

son tunnel junctions with a critical current density around 500 A/cm^2. We have also developed a design for reading out such qubits using inductive coupling. Results reflecting actual progress in this experiment will be presented.

[1] I. Chiorescu et al., Science **299**, 1869 (2003)
[2] S.P. Yukon, Physica C **368**, 320 (2002)
[3] J.I. Cirac and P. Zoller, Phys. Rev. Lett. **74**, 4091 (1995)

TT 26.23 Wed 14:30 P1

Long Josephson junction filters for qubit control — •H. H. Eglmeier[1], A. Kemp[1], V.S. Kaplunenko[2], and A. V. Ustinov[1] — [1]University of Erlangen-Nuremberg — [2]Stanford linear accelerator, metrol magnetic measurement

Josephson junctions have been demonstrated to perform as macroscopic quantum systems with a well-controlled Hamiltonian. Most superconducting qubits require magnetic flux control for their operation. One choice is to use rapid single flux quantum (RSFQ) logic for qubit control and interfacing with room temperature electronics.

Decoherence due to 1/f noise in the RSFQ circuitry leads to the need for efficient low-frequency isolation between the control circuitry and the qubit. We present characterization measurements and simulations of a novel low-pass filter based on a long Josephson junction.

An input signal fed into the long junction is transmitted only if its frequency exceeds the plasma frequency of the junction, otherwise it is attenuated as an exponentially vanishing (evanescent) wave. For qubit control one can use low frequency signals which are only transmitted as multiples of the flux quantum. The transmission properties of the filter in the GHz range are currently investigated experimentally.

TT 26.24 Wed 14:30 P1

Preparation and readout of bistable vortex states in a long annular Josephson junction containing a lithographic microshort. — •Alexander Kemp, Astria Price, and Alexey V. Ustinov — Physikalisches Institut III, Universitaet Erlangen-Nuernberg, Erlangen D-91058, Germany

We demonstrate classical state preparation and readout for a novel type of vortex qubit, in which a short section of the insulating barrier of a long annular Josephson junction is made slightly wider. This section of the junction acts like a microshort, where the height of the potential barrier so created can be tuned during experiment by varying the strength of an applied in-plane magnetic field. We develop a model for the double well potential, based on the one-dimensional sine-Gordon equation, in which the change in vortex rest mass energy due to the wider section of the junction is explicitly considered, and find the magnetic field dependence of the barrier height. Good agreement with measured vortex depinning currents from each well is obtained. The vortex was prepared in a given well by applying a series of "shaker" bias current pulses to the junction.

TT 26.25 Wed 14:30 P1

Frequency dependence of full counting statistics in AC-biased mesoscopic conductors — •Dmitry Bagrets[1] and Fabio Pistolesi[2] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128, Karlsruhe, Germany — [2]Laboratoire de Physique et Modélisation des Milieux Condensés, CNRS-UJF B.P. 166, F-38042 Grenoble, France

We develop a theory to obtain the current noise and the full counting statistics of charge transfer for AC biased mesoscopic conductors. We illustrate the theory by considering two specific examples: a diffusive wire and a chaotic quantum dot. We find that all cumulants of current fluctuations depend on the frequency Ω of the external AC field on the scale of the inverse diffusion time through the structure. This dependence stems from the multiple photon absorption processes and disappears when the AC voltage amplitude V is much smaller than $\hbar\Omega/e$ (e being the electron charge). The detection of the frequency dependence of the second cumulant, the current noise, is within reach of present experimental technology.

TT 26.26 Wed 14:30 P1

Full Counting Statistics of an Aharonov-Bohm Interferometer with an embedded Quantum Dot — •Daniel Urban and Jürgen König — Ruhr-Universität Bochum, 44780 Bochum, Germany

The electron's wave nature becomes apparent in Aharonov-Bohm interferometers, where constructive and destructive interference between two electron paths can be observed. The visivility of the Aharonov-Bohm signal provides information on the coherence of transport channels.

Correlations of electron transport are reflected in shot noise and higher moments of the current distribution. These reveal infomation not contained in the average current. All moments can be conveniently extracted from the Cumulant Generating Function, whose calculation is the aim of Full Counting Statistics (FCS).

Originally developed for situations without interaction FCS has recently been extended to strongly interacting systems such as quantum dots. Treating the coupling to the leads perturbatively, it was found that non-Markovian effects cannot be neglected [1]. We expand this scheme to describe a quantum dot embedded in an Aharonov-Bohm geometry.

[1] A. Braggio, J. König, and R. Fazio, cond-mat/0507527, submitted to Phys. Rev. Lett.

TT 26.27 Wed 14:30 P1

Revealing entanglement of spin qubits with counting statistics — •Holger Schaefers and Walter T. Strunz — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

We investigate two electron spin qubits in quantum dots. The spins are measured by separate currents through the dots. Our approach is based on quantum trajectories, widely used in quantum optics, here adapted to describe conditional quantum dot dynamics in a fermionic environment. We use the quantum trajectory approach to simulate the quantum dynamics conditioned on the continuous measurement outcome, here the electron currents through the dots. We propose a simple experiment and give a sufficient criterion for revealing entanglement with the help of counting statistics.

TT 26.28 Wed 14:30 P1

Molecular conductance from ab initio calculations: self energies and absorbing boundary conditions — •Andreas Arnold[1] and Ferdinand Evers[2] — [1]Institut für Theorie der kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe, Germany — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany

Calculating an exact self energy for ab initio transport calculations relevant to *Molecular Electronics* can be troublesome. Errors or insufficient approximations made at this step are a frequent reason why many molecular transport studies become inconclusive. We propose a simple and efficient approximation scheme, that follows from interpreting the self energy as an absorbing boundary condition of an effective Schroedinger equation. Our approximation is controlled by a small parameter, which essentially is the inverse number of electrode atoms, that are kept in the ab initio calculation.

The method is illustrated using a tight binding wire as a toy model, for which an analytical solution is available, against which we can check our numerical results. Also more realistic applications for transport calculations based on the density functional theory have been performed. They yield results in very good agreement with the conventional way to set up the electronic self energy.

TT 26.29 Wed 14:30 P1

Structure and conductance histogram of atomic-sized Au contacts — •Markus Dreher[1], Fabian Pauly[2], Jan Heurich[2], Carlos Cuevas[2,3], Elke Scheer[1], and Peter Nielaba[1] — [1]Physics Department, University of Konstanz, 78457 Konstanz, Germany — [2]Institut für Theoretische Festkörperphysik, University of Karlsruhe,76128 Karlsruhe, Germany — [3]Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021 Karlsruhe

Many experiments have shown that the conductance histograms of metallic atomic-sized contacts exhibit a peak structure, which is characteristic for the corresponding material. The origin of these peaks still remains as an open problem. In order to shed some light on this issue, we present a theoretical analysis of the conductance histograms of Au atomic contacts. We have combined classical molecular dynamics simulations of the breaking of nanocontacts with conductance calculations based on a tight-binding model. This combination gives us access to crucial information such as contact geometries, forces, minimum cross section, total conductance and transmission coefficients of the individual conduction channels.

The ensemble of our results suggests that the low temperature Au conductance histograms are a consequence of a subtle interplay between mechanical and electrical properties of these nanocontacts. At variance with other suggestions in the literature, our results indicate that the Au conductance histograms are not a simple consequence of conductance

quantization or of existence of exceptionally stable radii.

TT 26.30 Wed 14:30 P1

Absence of fractional conductance quantization in ferromagnetic atomic contacts — •Michael Häfner[1], Juan-Carlos Cuevas[1,2,3], Janne Viljas[1], Diego Frustaglia[3], and Fabian Pauly[1] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany — [2]Departamento de Física Teórica de la Materia Condensada C-V, Universidad Autónoma de Madrid, 28049 Madrid, Spain — [3]Quantum Transport and Information, Scuola Normale Superiore, 56126 Pisa, Italy

In this work we present a theoretical analysis of the current through atomic contacts of ferromagnetic materials (Co and Ni). Several experimental groups have recently reported the observation of half-integer conductance quantization in nanowires of these materials. This suggests that the current in these contacts is completely spin polarized and all the contributing channels are perfectly transmissive. In order to analyze these surprising observations, we have performed conductance calculations of Ni and Co atomic junctions based on a tight-binding model. Contrary to these experiments, we find that the conductance is in general neither quantized nor spin polarized. We show that the transport is mainly dominated by both the s and d bands close to the Fermi energy. These bands give rise to several conduction channels that are partially open. Typically, both spin bands give a significant contribution to the transport suggesting that the fractional conductance quantization should not appear in ferromagnetic atomic contacts.

TT 26.31 Wed 14:30 P1

Influence of vibrations on electronic transport through DNA — •Benjamin Schmidt[1,2], Matthias Hettler[2], Gerd Schön[1,2], E.B. Starikov[2], and Wolfgang Wenzel[2] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, 76128 Karlsruhe, Germany — [2]Institut für Nanotechnologie, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany

Conductance measurements on DNA 'wires' display various types of behavior ranging from insulating over semi-conducting to quasi-metallic, depending on the measurement setup and the measured DNA molecule. The variance of the experimental results as well as ab-initio calculations suggest that the environment and vibrational modes of DNA have a dominating influence on the transport properties of DNA wires. In this work we study transport through simple models of homogeneous DNA wires (poly-DNA) using standard Green function technique and Landauer-Buettiker formalism. In particular, we address the influence of specific DNA vibrational modes (with parameters determined by ab-initio methods) on transport in the presence of an environment described by a general bosonic bath. We can describe the crossover from semi-conducting to quasi-metallic behavior in dependence of temperature and the electronic coupling to the vibrational modes and bath.

TT 26.32 Wed 14:30 P1

Influence of Adsorbates on the Structure and Electronic Properties of Molecular-size Junctions — •Sören Wohlthat[1], Fabian Pauly[1], Janne Viljas[1], Juan-Carlos Cuevas[2,1,3], and Gerd Schön[1,3] — [1]Institut für Theoretische Festkörperphysik, Universität Karlsruhe, D-76128 Karlsruhe — [2]Departamento de Física Teórica de la Materia Condensada C-V, Universidad Autónoma de Madrid, E-28049 Madrid, Spain — [3]Forschungszentrum Karlsruhe, Institut für Nanotechnologie, 76021 Karlsruhe

During the last few years, the conduction properties of molecuar-size contacts between two metallic leads have attracted a great deal of attention. Motivated by recent experiments concerning the effect of hydrogen [1] and oxygen [2] on metallic nanocontacts, we investigate theoretically the influence of adsorbates on this type of junctions. We analyse the stability of different geometries and determine their electronic transport properties. The calculations are based on density functional theory (DFT) using the quantum chemistry package TURBOMOLE. The electronic transport properties are obtained by non-equilibrium Green's function (NEGF) techniques. Our simulations show that adsorbates have a significant influence on the properties of our molecular-size junctions and that they could serve as design tools for future atomic and molecular circuits.

[1] R.H.M. Smit et al., Nature 419, 906, (2002).
[2] W.H.A. Thijssen et al., cond-mat/0509376.

TT 26.33 Wed 14:30 P1

First-principles study of single row Al and Pt wires — •Thomas Gnielka[1,2], Klaus-Peter Bohnen[1], and Rolf Heid[1] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe — [2]Universität Karlsruhe, Fakultät für Physik, D-76128 Karlsruhe

Over the past several years there has been a great deal of interest in the physical properties of atomic wires. Although there have been some studies of the structural and electronic properties of nanowires so far lattice dynamics of these systems has been hardly studied. This is in strong contrast to the importance of lattice dynamics for structural stability (Peierls transition) and superconductivity. Thus we have investigated the lattice dynamics, the atomic and electronic structures and the relation between them for single-row Al and Pt wires using density-functional theory. The calculations reveal that the wires transform from planar zigzag structure to linear and further to dimerized wires during elongation. Phonon dispersions have been calculated and anomalies nicely correlate with Fermi surface nesting effects. Dimerization effects as seen for Pt wires on Ge(100) seem to be qualitatively in agreement with these findings, however the substrate influence has still to be studied. Prelimenary results seem to indicate the importance of substrate effects.

TT 26.34 Wed 14:30 P1

Transport properties of carbon nanotubes synthesized by chemical vapor deposition — •T. Pietsch, I. Mönch, J. Schumann, K. Biedermann, H. Vinzelberg, and B. Büchner — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

The electrical properties of multiwalled carbon nanotubes (MWCNT) synthesized by chemical vapor deposition (CVD) depend on the used CVD method. In this work we investigate MWCNT with outer diameters from 30 to 60 nm and length over 6 μm grown by a thermal-catalytic CVD method. TEM images show that the concentric layers of the nanotubes are not perfect. The MWCNT devices for the transport measurement with low ohmic contacts were prepared by using an ac-electrophoresis deposition either on Ti-microfinger structures followed by a HV annealing at 800°C or on oxidized silicon wafers with prestructured leads, electron beam lithography, oxygen plasma treatment and evaporated Cr/Au contacts on the nanotubes. The contact resistance are for the Ti contacts about 50 kΩ and for the Cr/Au contacts smaller than 1 kΩ. The average intrinsic room temperature resistance of the MWCNT measured in four-point configuration is 1500 $\mu\Omega$cm and comparable to that of natural graphite of 1350 $\mu\Omega$cm. At room temperature the current-voltage characteristics are linear but at low temperatures not linear. The temperature coefficient of the zero-bias resistance in the temperature range between 300K and 4.2K is negative. Positive magnetoresistances at 4.2K of about 2 % at 8T were measured. The results show that - caused by the defect structure of the MWCNT walls - the conduction is diffusive.

TT 26.35 Wed 14:30 P1

Transport through molecules — •Bernd Briechle, Simon Verleger, and Artur Erbe — Universität Konstanz, Fachbereich Physik, 78457 Konstanz

The aim of our studies is the characterisation of electronic transport through a single or a few molecules. It is important that the coupling of the molecules to the electrodes is mechanically and electronically stable throughout the experiment. As a first step two different structures allowing for the change of the mechanical coupling will be analysed to find an optimal configuration. On the one hand a mechanically controllable break-junction (MCB) technique will be studied, on the other a shadow evaporation technique based on a silicon structure will be tested. Transport through the molecules can be investigated at different temperatures. Additionally the integration of a gate electrode for detailed characterisation of the charge transport is in preparation.

TT 26.36 Wed 14:30 P1

Hofstadter butterfly of carbon nanotubes — •Norbert Nemec and Gianaurelio Cuniberti — Institut für theoretische Physik, Universität Regensburg, 93040 Regensburg

The electronic spectrum of a two dimensional square lattice in a perpendicular magnetic field, known as Hofstadter butterfly, was discovered in Regensburg thirty years ago [1]. We have calculated the Hofstadter butterfly for carbon nanotubes (CNTs) in the tight-binding approximation. For the case of single wall CNTs, it is straightforward to imple-

ment magnetic fields parallel to the tube axis by means of zone-folding in the graphene reciprocal lattice. We have also studied perpendicular magnetic fields which, in contrast to the parallel case, lead to a much richer, non-periodic spectrum. Moreover, we have investigated magnetic fields piercing double-wall CNTs and found strong signatures of inter-shell interaction in the resulting butterfly-spectrum. Ubiquitous to all perpendicular magnetic field spectra is the presence cusp-catastrophes at specific values of energy and magnetic field. At these particular points, the electronic wave function can be correspondingly visualized.
[1] D. Hofstadter, Phys. Rev. B 14, 2239 (1976)

TT 26.37 Wed 14:30 P1

Signatures of vibron-assisted transport in DNA molecular wires — •Rafael Gutierrez[1], Sudeep Mandal[1], Soumya Mohapatra[1], Danny Porath[2], and Gianaurelio Cuniberti[1] — [1]Molecular Computing Group, University of Regensburg, D-93040 Regensburg, Germany — [2]Physical Chemistry Department, The Hebrew University, 91904, Jerusalem, Israel

We investigate the coupling of tunneling charges to intrinsic or extrinsic vibrational degrees of freedom in model Hamiltonians which effectively mimic the low-energy electronic structure of DNA molecular wires. We especially discuss two cases: (i) interaction with an external dissipative bosonic bath, and (ii) coupling to intrinsic vibrational modes. The first case can be relevant to experiments in aqueous solution, see e.g. B. Xu et al., Nano Lett. 4, 1105 (2004). The second case takes into account the influence of intrinsic dynamical fluctuations of the double helix on a propagating charge. Our results suggest that in the recent experiments of H. Cohen et al., Proc. Natl. Acad. Sci. (USA) 102, 11589 (2005) on short suspended DNA wires, vibrational modes might give a non-negligible contribution in determining the measured high currents.

TT 26.38 Wed 14:30 P1

Effects of chemical substitution on quantum transport through single aromatic molecules — •Florian Pump[1], Alessandro Pecchia[2], Aldo Di Carlo[2], and Gianaurelio Cuniberti[1] — [1]Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany — [2]INFM and Department of Electronic Engineering, University of Rome "Tor Vergata"I-00133 Rome, Italy

Recent experimental investigations show that the measurement of unimolecular transport is possible. Still, signatures of truly molecule-mediated quantum transport have to be selectively identified in experiments and their theoretical mechanisms need to be understood. Such signatures can be obtained by separating an aromatic molecule into two electronically different parts. This can be attained by the substitution of certain H-atoms asymmetrically on one side of phenylene ethynylene based molecules by atoms with larger electronegativity (e.g. F). Then, the π-conjugation can be broken by means of steric repulsion groups like NO_2 and/or CH_3. Depending on the position of these groups on the molecule, it is possible to further engineer electrical dipoles able to incrementally break the π-conjugation in response to an external electric field. We have thus investigated nonlinear quantum transport through phenylene ethynylene based molecules as a function of a gatable intramolecular coupling to understand the role of chemical substitution on the observable nonequilibrium electrical current. Contacts to the recent experiments by Elbing *et al.* [1] are also provided.
[1] M. Elbing *et al.*, Proc. Natl. Acad. Sci. USA **102**, 8815 (2005).

TT 26.39 Wed 14:30 P1

Quantum transport through single azobenzene molecules: contact effects — •Miriam del Valle[1,2], Rafael Gutiérrez-Laliga[2], Carlos Tejedor[1], and Gianaurelio Cuniberti[2] — [1]Dpto. Física de la Materia Condensada, Universidad Autónoma de Madrid, Spain — [2]Institute of Theoretical Physics, Universität Regensburg, Germany

We investigate the transport properties of azobenzene, a photosensitive molecule which could provide a light-driven switch. The I–V characteristics are studied in the linear response regime using first-principle methods and Green function techniques. Focus is made on the effect of contacts such as gold leads or carbon nanotubes. The trans configuration of this molecule proves to be a better conducting element than its metastable cis configuration. Remarkable is that zigzag carbon nanotubes have a strong effect of enhancement in the current features up to four orders of magnitude.

TT 26.40 Wed 14:30 P1

STM spectroscopy and STM imaging of linear molecules — •Dmitry Ryndyk and Gianaurelio Cuniberti — Molecular Computing Group, Institute for Theoretical Physics, University of Regensburg, Germany

Inelastic tunneling spectroscopy (IETS) in combination with scanning tunneling microscopy (STM) is a powerful method to investigate electronic spectrum and transport properties of large molecules. We consider theoretically nonequilibrium electronic transport through a single molecule placed between a conducting substrate and an STM tip at finite voltages. A semi-empirical tight-binding model is used to describe linear molecules (as DNA). The STM based molecular junction is considered as a strongly asymmetric double tunnel junction. The molecule is weakly coupled to the substrate and to the STM tip. The coupling of the different parts of the molecule to the STM tip is a function of the distance, which results in a tunneling current dependence on the position of the STM tip (STM image of the molecule). In the limit of small voltages the conductance of nonmetallic molecules is very small and determined by environ-mentally induced states. At finite voltages resonant transport through molecular orbitals gives peaks in the differential conductance as a function of the voltage. The nonequilibrium Green function method is applied to calculate the contribution of different molecular orbitals at finite voltages. It is shown that molecular spectra are modified by charging and vibrational effects.

TT 26.41 Wed 14:30 P1

Influence of laser irradiation on the transport in molecular wires — •U. Kleinekathöfer, S. Welack, and M. Schreiber — Institut für Physik, Technische Universität Chemnitz, 09107 Chemnitz

The electron transport through a molecular wire under the influence of an external laser field is studied using a reduced density matrix formalism [1]. The full system is partitioned into the relevant part, i.e. the wire, electronic reservoirs and a thermal phonon bath. An earlier second-order perturbation theory approach of Meier and Tannor for bosonic environments which employs a numerical decomposition of the spectral density is used to describe the coupling to the phonon bath and is extended to deal with the electron transfer between the reservoirs and the molecular wire. Furthermore, from the resulting time-nonlocal (TNL) scheme a time-local (TL) approach can be derived. Both are employed to propagate the reduced density operator in time for a time-dependent system Hamiltonian which incorporates the laser field non-perturbatively. In addition, an optimal control algorithm designed for open quantum systems is employed in order to compute optimal laser control fields to control the current through the wire.
[1] S. Welack, M. Schreiber and U. Kleinekathöfer, cond-mat/0509442.

TT 26.42 Wed 14:30 P1

Nanometer spaced electrodes of different metals on cleaved surfaces for molecular electronics applications — •Simone Lingitz, Sebastian Luber, Fan Zhang, Allan Hansen, Max Bichler, and Marc Tornow — Walter Schottky Institut, TU München, 85748 Garching, Germany

Current efforts in molecular electronics both aim for novel devices as well as the understanding of the electronic transport in molecules. Here one of the major challenges is the preparation of defined electrodes which allow reliably contacting and electrically investigating molecules of a given size. We pursue a novel strategy to fabricate nanometer spaced metal electrodes which is based on the cleavage plane of a GaAs-AlGaAs heterostructure.

Using Molecular Beam Epitaxy (MBE) we embedded a 5nm-GaAs layer in between two AlGaAs layers. By cleaving the substrate and selectively etching the GaAs layer, the remaining AlGaAs layers act as a support for deposited metal electrodes. We also used an inverse template structure (AlGaAs layer within GaAs) to profit from the unsurpassed selectivity of HF based etchants. In both approaches the electrode distance is precisely predetermined and various electrode metals can be used. This provides a platform to investigate the alignment of molecular and metal energy levels. In our contribution we will report on electrical investigations on thiolated @\pi@-conjugated aromatic molecules assembled on 5nm spaced gold electrodes. Here the current-voltage characteristics show an exponential like increase in current at voltages above approx. 0.3V. We compare this to similar investigations on platinum electrodes.